Finding Best Practices in the Literature or TUESdays with Jason, Dave, Robin and Steve

Jason D'Acchioli and Robin Tanke,
Chemistry, UW Stevens Point

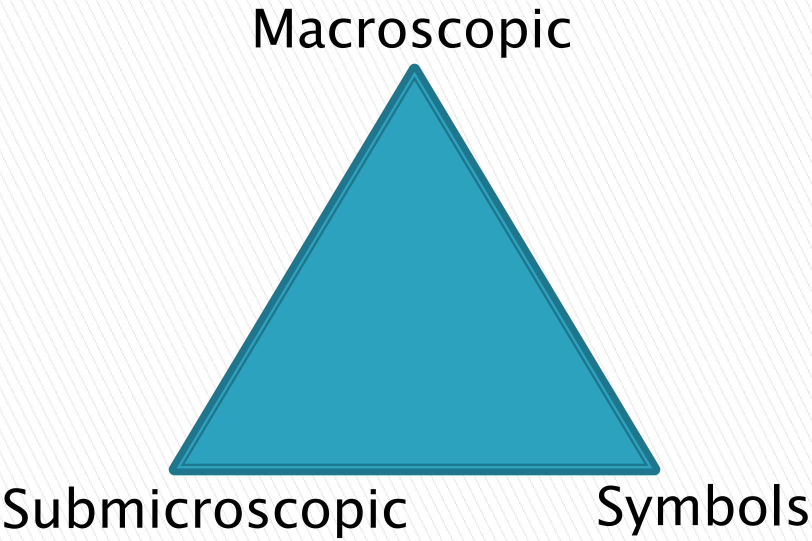
September 28,2012

Outline

- Why the group formed
- Some interesting things we learned
  - Particle Nature of Matter (Robin)
  - Teaching Science or Teaching about Science (Jason)
- How the literature impacted our own teaching
- How the literature influenced our grant proposal.

Levels of thought

(Johnstone, A.H., *Why is Science difficult to learn? Things are seldom as they seem.* Journal of Computer Assisted Learning, 1991. 7: p. 75-83.)



- Experts move easily around the triangle; amateurs do not.
- Can students solve problems w/o understanding concepts?
- How can something that looks continuous be discrete?

Nurrenbern, S.C. and M. Pickering, *Concept-Learning Versus Problem-Solving – Is There a Difference.* Journal of Chemical Education, 1987. 64(6): p. 508-510. UM-Kanas City and UW-Stout 1st Sem

- <u>Traditional Stoichiometry</u>

Calculate the maximum weight of SO_3 that could be produced from 1.9 mol of oxygen and excess sulfur.

$$2S + 3O_2 \rightarrow 2\ SO_3$$

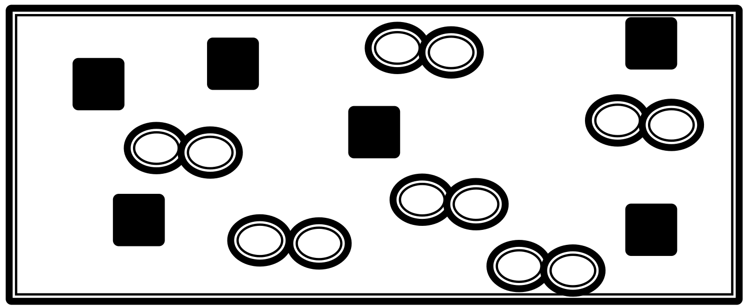
Solution:

1.9 mol O_2 x 2 mol SO_3/3 mol O_2 x 80 g SO_3/mol =

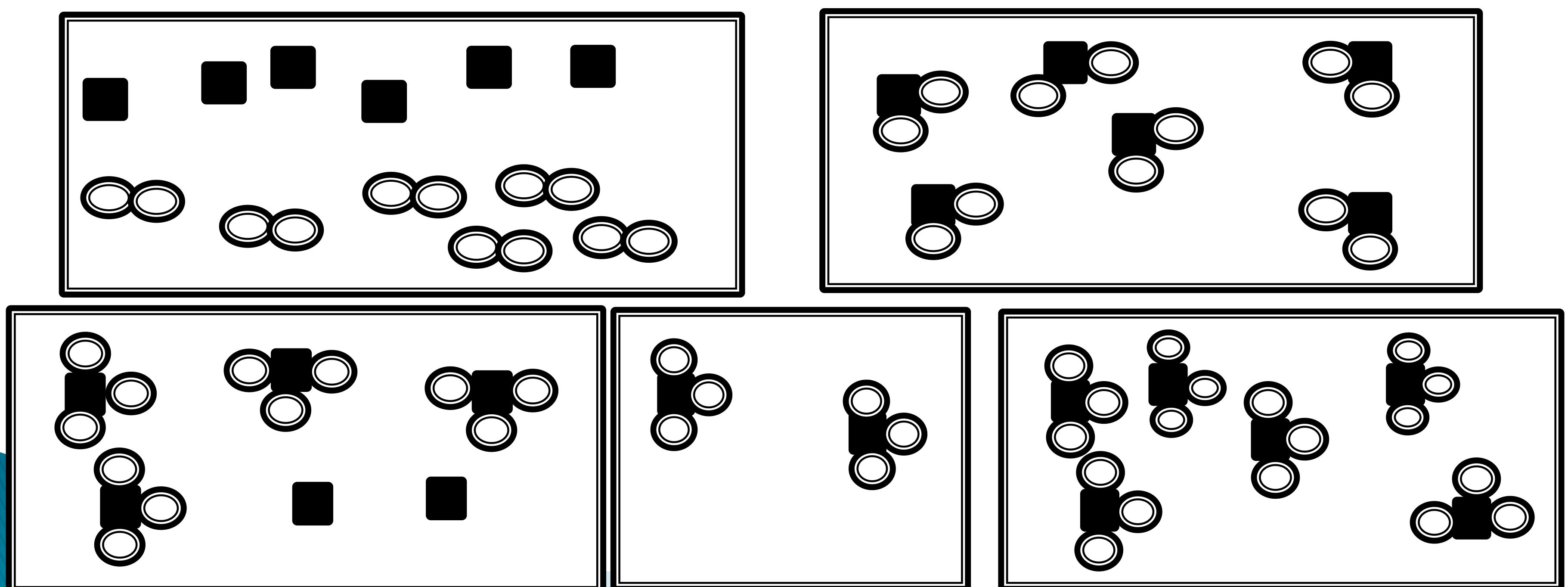
Conceptual Stoichiometry

The equation for a reaction is $2S + 3O_2 \rightarrow 2\ SO_3$

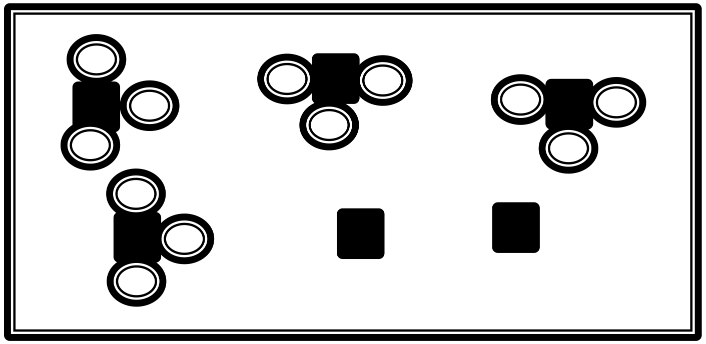
Consider a mixture of S (■) and O_2() in a closed container as illustrated below



Which of the following represents the product mixture?



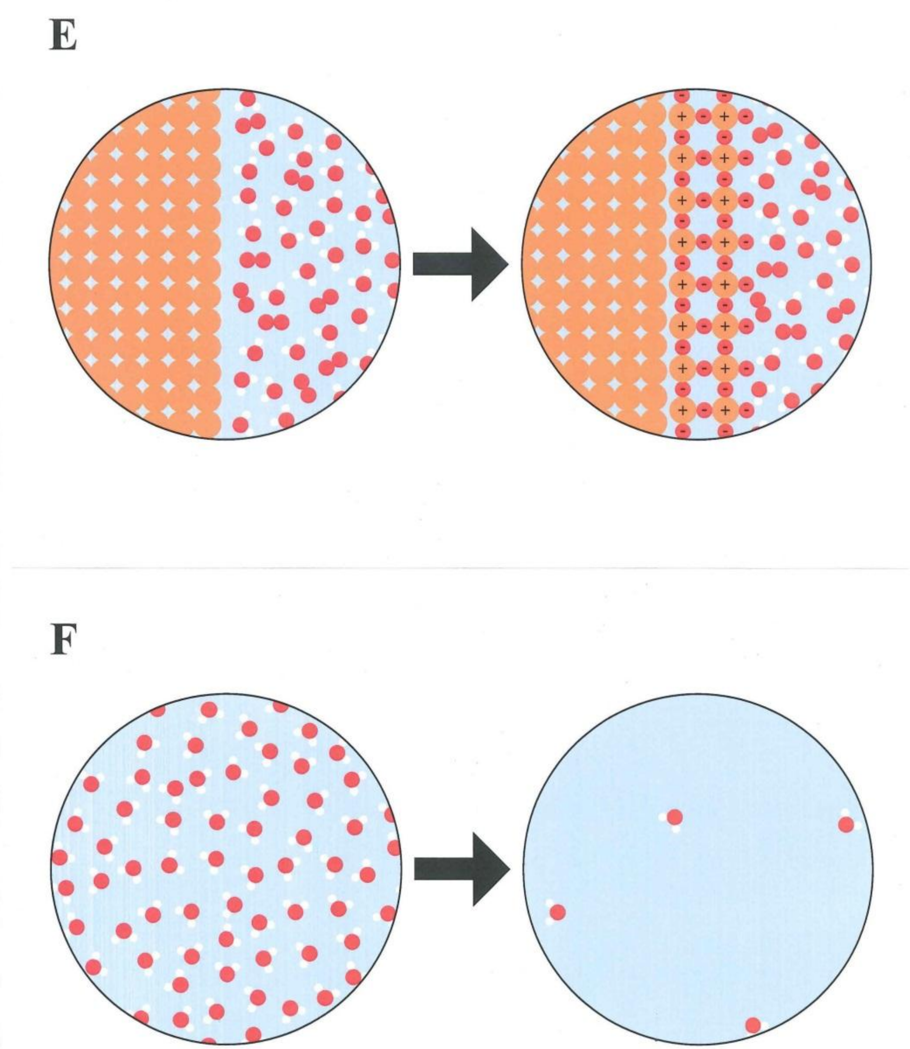
The Correct Answer



- For 200 students, 98 got the traditional problem correct, only 58 got the conceptual problem correct.
- <u>Is the solution teaching more conceptual learning?</u>

Materials to Consider Using

- Grand Valley State University Target Inquiry Teaching Materials http://www.gvsu.edu/ targetinquiry
- Change you can believe in (2009, Chad Bridle, Grandville High School)



Materials to Consider Using

- PaNoMA Supplement to Yezierski, E.J. and J.P. Birk, *Misconceptions about the particulate nature of matter.* Journal of Chemical Education, 2006. **83**(6): p. 954-960.

A pot of water is placed on a hot stove. Small bubbles begin to appear at the bottom of the pot. The bubbles rise to the surface of the water and seem to pop or disappear. What are the bubbles made of?

A. heat

B. air

C. gaseous oxygen and hydrogen

D. gaseous water

E. none of the above

A pot of water on a hot stove begins to boil rapidly. A glass lid is placed on the pot and water droplets begin forming on the inside of the lid. What happened?

A. The lid became sweaty.

B. Steam cools and water molecules moved closer together.

C. Water from outside leaked into the pot.

D. Hydrogen and oxygen combined to form water.

E. Steam combined with the air to wet the inside of the lid.

Studies and their results

Exposure and practice with particle drawings is required for success; misinterpretation is easy.

Students need time to develop an understanding of the particle nature of matter.

Transitions between macroscopic and molecular representations should be explicitly conveyed to students

Gender Differences

- Bunce and Gabel found that females improved scores on achievement tests that narrowed the gender gap when taught about matter with symbols, particles and macroscopic images.
- Yezierski and Birk found that both males and females decreased their misconceptions about the particle nature of matter after learning with computer animations depicting the particle behavior of water; however, females showed greater improvement narrowing the gender gap.

1. Bunce, D.M. and D. Gabel, *Differential effects on the achievement of males and females of teaching the particulate nature of chemistry.* Journal of Research in Science Teaching, 2002. **39**(10): p. 911-927.
2. Yezierski, E.J. and J.P. Birk, *Misconceptions about the particulate nature of matter.* Journal of Chemical Education, 2006. **83**(6): p. 954-960.

Application to Teaching

- Use images and animations of the particle nature of matter to improve student explanations of chemical phenomena.
- Assess students on the particle nature of matter.
- Remember that students have a hard time switching between particles, symbols and macroscopic descriptions – find ways to help them develop this skill.
- Proposal for a X-ray diffractometer so students “see” the validity of the particle model.

What is the purpose of science?

- Using traditional science curricula, “science is *not* being taught. Information about science, training in using the products of science, and perhaps some history of science may be taught, but science as the discipline seems to be structured is not being taught .”
  - J.W. Renner, “The Power of Purpose”, *Science Education*, **66**, 1982, 709–716.

Renner's dichotomy

- Theory A: Mastery of content as given to them by a teacher (*inform, verify, practice*)
- Theory B: Leading students to develop their own understanding of the content (*exploration, intervention, experiences*)

Are we covering material, or are we uncovering it?

TUES proposal: Bridging a gap between A and B

- Students accept what they can “see” and “touch”
- How do you “see” and “touch” a single molecule? X-ray diffraction, and other spectroscopies
- By putting particulate matter in the hands of students, we (hopefully) are giving them the data for a glimpse into the molecular world

In practice:
A current laboratory experiment

- Introduction to molecular structure lab
- Students currently a) draw Lewis structures and b) build structures with model kits
- Students get various chemical information, including practice with Lewis structures and information on molecular geometry
- At no point is experimental data used (real bond lengths, angles, etc.)

In practice:
A redesigned laboratory experiment

- Students given skeletal Lewis structures of several compounds to complete
- Students will crystallize several benzoic acid derivatives for single-crystal X-ray diffraction
- Students will use the experimental data (bond lengths, angles, etc.) to explain bond lengths, angles, etc. in their skeletal structures, **and** to explain other phenomena, such as resonance theory

A *personal* difficulty: Something to reflect on

- Held biases versus the reality of a situation
- Is there a data-driven “risk”, especially as a new faculty member? Teaching evaluations versus belief
- How do you bring science, as *research*, into a 100-level course?
- The evolution of a teacher—how long does it take to “see the light”?

Acknowledgements

- Steve Wright
- Dave Snyder
- Comments from other presenters
- Questions from the participants

Distillation Data for Four Liquids

Distillation Data		Distillation Data		Distillation Data		Distillation Data	
Distilling 70.0 grams of "Liquid One"		Distilling 70.0 grams of "Liquid Two"		Distilling 70.0 grams of "Liquid Three"		Distilling 70.0 grams of "Liquid Four"	
Mass of distillate collected in grams	Boiling Temperature in degrees Celsius	Mass of distillate collected in grams	Boiling Temperature in degrees Celsius	Mass of distillate collected in grams	Boiling Temperature in degrees Celsius	Mass of distillate collected In grams	Boiling Temperature in degrees Celsius
15.0	55.9	15.0	56.1	15.0	79.8	15.0	34.9
16.0	56.0	16.0	56.2	16.0	79.9	16.0	34.8
17.0	56.1	17.0	55.9	17.0	80.0	17.0	34.9
18.0	55.8	18.0	56.0	18.0	80.0	18.0	35.0
19.0	56.2	19.0	56.0	19.0	80.0	19.0	35.1
20.0	56.0	20.0	56.1	20.0	80.1	20.0	35.1
21.0	55.9	21.0	56.2	21.0	80.1	21.0	35.1
22.0	56.2	22.0	55.9	22.0	80.2	22.0	34.9
23.0	55.9	23.0	55.8	23.0	80.2	23.0	34.8
24.0	56.3	24.0	55.9	24.0	80.1	24.0	34.9
25.0	56.0	25.0	56.0	25.0	80.0	25.0	34.8
26.0	55.8	26.0	56.1	26.0	80.0	26.0	35.0
27.0	55.9	27.0	56.2	27.0	80.0	27.0	35.0
28.0	56.1	28.0	56.2	28.0	79.8	28.0	35.1
29.0	56.0	29.0	56.1	29.0	79.8	29.0	35.2
30.0	55.9	30.0	56.0	30.0	79.9	30.0	35.1
31.0	79.8	31.0	56.0	31.0	80.1	31.0	55.8
32.0	79.9	32.0	55.9	32.0	80.1	32.0	55.9
33.0	80.0	33.0	55.9	33.0	80.2	33.0	55.9
34.0	79.9	34.0	55.8	34.0	80.0	34.0	55.9
35.0	80.1	35.0	56.0	35.0	80.1	35.0	55.8
36.0	79.8	36.0	56.0	36.0	80.2	36.0	55.8
37.0	80.2	37.0	55.9	37.0	80.0	37.0	56.1
38.0	79.9	38.0	56.1	38.0	80.2	38.0	56.2
39.0	80.0	39.0	56.2	39.0	79.8	39.0	56.2
40.0	79.9	40.0	55.9	40.0	79.8	40.0	56.1
41.0	80.2	41.0	79.9	41.0	79.9	41.0	56.1
42.0	80.0	42.0	79.9	42.0	79.8	42.0	56.0
43.0	79.8	43.0	79.8	43.0	79.8	43.0	56.0
44.0	80.2	44.0	80.0	44.0	80.0	44.0	56.0
45.0	80.1	45.0	80.1	45.0	79.9	45.0	56.1
46.0	80.0	46.0	80.2	46.0	79.8	46.0	80.0
47.0	80.1	47.0	79.9	47.0	80.1	47.0	79.9
48.0	79.9	48.0	79.8	48.0	80.1	48.0	79.8
49.0	79.8	49.0	80.0	49.0	80.2	49.0	79.9
50.0	80.0	50.0	80.1	50.0	80.2	50.0	80.0
All distillations were discontinued at this point. Assume all boiling temperatures would remain essentially unchanged for the remainder of the distillation.							

Traditional Labs

- Teaches
  - how to follow directions
  - how to keep a lab notebook
  - how to write a report
  - how to prove equations given in the text

Scientific Community Labs

- Students decide:
  - what data to gather
  - how to gather data
  - how to analyze data
  - how to present data to peers

Lab Instructions

Thanks to your legendary skill at designing clown launchers, you have recently been hired by a famous Hollywood movie studio to design some special effects. They are going to film a giant meteor crashing into the Earth, but in order to make it look realistic, they have to know an accurate value of the acceleration due to gravity.

For most physics problems, we sometimes use 9.8 or 10 m/s^2 for our g value. This is an approximation. The actual value of g can vary depending on your global latitude, altitude, and the geography of the area. For this stunt, you will need to be able to determine g in several different filming locations, and to alter the safety nets and wires accordingly. In this lab, you've been given the task of measuring g in your lab room in the physics building well enough that you could tell if g changed by 1 percent or less.

Question:

What is g in this room?
How precise is this figure?

This week will be devoted to data-taking. Design an appropriate experiment to measure g and determine how well you can measure this figure. Next week you will pool your data together with the rest of the class.

I. Introduction	**5 min**	**Whole class**

A group of students has decided to measure the speed of a battery powered toy car. It takes the car an average of 6.34 seconds to travel 1 meter, so they report a speed of 15.8 cm/sec. Another group measures the speed of the same car to be 14.6 cm/sec. Do the results of these two groups agree or disagree? (Hint: Use your experience from lab to estimate the range of each group's uncertainty.)

II. Brainstorm and plan	**15 min**	**Groups of 4**
III. Carry out the experiment	**80 min**	**Groups of 4**
IV. Evaluate your experiment	**20 min**	**Groups of 4**